

### REMARKS

This amendment is responsive to the Office Action of April 4, 2006. Reconsideration and allowance of claims 1-19 are requested.

### The Office Action

Claims 1-7 and 9 stand rejected under 35 U.S.C. § 103 as being unpatentable over Leussler (WO 02/095435) in view of Boskamp (Whole Body LPSA Transceive Array with Optimized Transmit Homogeneity).

Claim 8 stands rejected under 35 U.S.C. § 103 as being unpatentable over Leussler, in view of Boskamp, further in view of Bock (US 6,549,799).

### Background

For several years, one of the most common magnetic resonance (MR) imaging systems was based on a birdcage coil. A single RF transmitter would generate a single resonance excitation or manipulation pulse which would be applied to a quadrature splitter and applied to the birdcage coil. One or more RF pulses were applied by the coil to excite and manipulate resonance in preparation for reading out a magnetic resonance signal. Each magnetic resonance signal read out by the birdcage coil or a surface coil was processed to generate one line of k-space.

It is well-known by those of ordinary skill in the art that the RF pulses applied to the birdcage coil to induce or manipulate resonance are very large and many times the amplitude of the detected resonance signals which are read out. To prevent damaging or destroying the receiver, a transmit/receive switch system is commonly used to prevent the magnetic resonance excitation and manipulation pulses from being passed to the receiver. That is, when the same coil is used for both transmit and receive, the receiver is actively connected to the coil only in the receive mode and is prevented from receiving signals during the transmit mode.

For various reasons, it is advantageous to have a plurality of individual resonator elements surrounding the imaged subject rather than a birdcage or other signal coil. It is further advantageous, as shown by **Leussler** and **Boskamp**, to drive each of the resonator elements with an RF signal whose amplitude and phase are individually selected. Neither Leussler nor Boskamp focus on how to drive the

resonator elements with signals with individually controlled amplitude and phases, but both give exemplary circuits for doing so. Other than in the level of detail, Leussler and Boskamp show substantially identical circuits.

In both Leussler and Boskamp, a unit (transmission unit 106 in Leussler; 16 way power splitter in Boskamp), receives a single signal and divides it among a plurality of channels (8 in the illustrated example in Leussler; 16 in the illustrated example in Boskamp). The amplitude and phase of the signal in each of the individual channels is controlled (by control unit 108 in Leussler; 16 attenuators and 16 phase shifters in Boskamp). Although Leussler does not explain the circuitry with which the amplitude and phase of each channel are adjusted, the applicants will agree that many in the art would select an attenuator and phase shifter for each channel as shown by Boskamp). The amplitude and phase-shifted signal in each channel is amplified by a corresponding power amplifier (power amplifiers 107 in Leussler; 16 1 kW power amps in Boskamp). In the transmit mode, a transmit/receive switch (S in Leussler; T/R switches in Boskamp) connect the output signal from each transmit channel to a corresponding one of the resonator elements (resonator elements 104 in Leussler; unnumbered in Boskamp). The function of the transmit/receive switches are explained at column 7, lines 29-33 of Leussler. That is, in the transmit mode, the transmit/receive switch S connects its corresponding resonator element 104 to one of the transmit channels 1-8. In the receive mode, the transmit/receive switch S connects the corresponding resonator element 104 to a corresponding one of receive channels a-h. Each receive channel processes the signal from its corresponding resonator element individually.

**THE T/R SWITCH ELEMENTS OF BOSKAMP DO NOT ACT AS A MULTIPLEXER/DISTRIBUTOR.** The transmit/receive switches connect the amplified resonance excitation and manipulation signals of a corresponding channel to a corresponding element of the resonator in the transmit mode and connect each resonator to a receive channel in the receive mode. Neither Leussler nor Boskamp disclose or fairly suggest that the transmit/receive switches perform any multiplexing function nor function to distribute the transmission RF power among the transmission RF channels. Rather, those of ordinary skill in the art would instantly recognize that the transmit/receive switches merely protect the very sensitive receive channels from

the very high power transmitted RF signals during the transmit mode. No other purpose is ascribed to the transmit/receive switches by either Leussler or Boskamp.

Leussler does have an alternative embodiment, shown in phantom in Figure 1, in which there is a single power amplifier **110**. The distribution, amplitude, and phase adjustment are then performed on the high power RF signal rather than the lower power RF signal as shown in the first embodiment of Leussler and in Boskamp. These two embodiments are **ALTERNATE** embodiments and Leussler makes no suggestion that one should nor how one might combine these two **ALTERNATE** approaches. The Leussler reference does not contain any motivation to modify one of these alternate approaches in view of the other.

**Bock** was not applied against independent claim 1 and need not be discussed at the present time.

### The Present Application

The present application is directed to improvement over Leussler and Boskamp. In the first embodiment of Leussler, the power amplifiers **107** must be sufficiently large or powerful to supply the maximum amplitude which each of the resonator elements **104** might require. Similary, the 16 1-kW power amplifiers of Boskamp must also meet this maximum potential power requirement.

By way of example, in a 7 Tesla magnetic resonance imaging system, the patient **102** alters various electromagnetic conditions in the bore such that it may be advantageous to apply a signal of 100% of the nominal signal strength to one of the resonators, a signal of 110% of the nominal signal strength to another, and a signal of only 90% of the nominal strength to yet another. In order to meet such demands, the amplifiers **107** of the first embodiment of Leussler and the power amplifiers of Boskamp must be oversized to meet these potential higher than nominal power requirements. In the alternate embodiment of Leussler, the power amp **110** must be at least 8 times the maximum potential power requirement per channel such that the attenuators in each channel can reduce the maximum potential amplitude signal that any resonator might require down to the actual required amplitude. In the present application, by adjusting the percentage of the signal which is distributed to each power amplifier **107** and the percentage of the signal from each power amplifier

which is distributed to each resonator element, an individual resonator element may receive a higher power signal than can be supplied by any one of the amplifiers 107. It should also be noted that although the number of amplifiers in the illustrated embodiment is the same as the number of channels, there could be a smaller number of amplifiers or a larger number of lower powered amplifiers. Further, all of the amplifiers do not need to be the same size. In one particularly described application, the output from all of the amplifiers can be combined into a single transmit channel to yield a single output signal with very high power.

The present application also describes an embodiment in which the amplification factors are dynamically and automatically varied. Pick-up coils 111 measure the RF field distribution which is actually applied to the volume 100 and feed this information back 112 to the control unit 110 such that it can dynamically adjust the relative amplitudes on each of the channels to optimize the RF field distribution actually achieved within the examination region.

**The Claims Distinguish Patentably  
Over the References of Record**

**Claim 1** calls for a plurality of high-frequency amplifiers. The second embodiment of Leussler is designed for a system with only a single high-frequency amplifier 110.

Claim 1 further calls for controllable multiplexer distributor networks both upstream and downstream from the plurality of amplifiers. By contrast, both the first embodiment of Leussler and the embodiment of Boskamp have only a single distribution network, which single distribution network is disposed upstream of the high-frequency amplifiers. Further, there is no suggestion in either Boskamp or Leussler that the 16-way power splitter or the transmission unit 106 are controllable or have any ability to change the relative distribution with which the single received signal is split among the channels.

The second embodiment of Leussler does not cure these shortcomings. The second embodiment of Leussler suggests at best that one may place the single distribution unit downstream of the power amplifier in the situation in which there is only a single power amplifier. There is no suggestion of two distribution units, much

less of distributions both upstream and downstream from a plurality of power amplifiers.

Because neither Leussler nor Boskamp disclose either a controllable multiplexer/distribution network nor a pair of distribution networks, one upstream and the other downstream from a plurality of amplifiers, it is submitted that **claim 1 and claims 2-10 dependent therefrom** distinguish patentably and unobviously over the references of record.

**Claim 2** emphasizes these differences by calling for a control unit for the multiplexer/distributor networks. Leussler provides no detail, and to the extent that the detail is supplied by the 16-way power splitter of Boskamp, there is no suggestion in Boskamp (or Leussler) that this power splitter splits the power anything other than a fixed and uncontrollable ratio, particularly evenly.

**Claim 3** calls for adjusting the gain factor of each amplifier. The Examiner refers the applicants to page 8, lines 1-3 of Leussler (although the applicants believe the Examiner meant to refer to lines 3-4). However, these lines do not call for adjusting the gain of the amplifiers **107**. Rather, they call for adjusting the amplitude and the phase of the RF signal in control units **108** which are upstream of each amplifier, e.g., attenuators as shown in Boskamp.

**Claim 4** calls for measurement sensors connected with the control unit that controls the high-frequency field strength. The Examiner refers the applicant to sensors **117** of Leussler. Coils **117** of Leussler are surface coils which are part of the imaging system. The signals received by coils **117** of Leussler are input into inputs *i, j* of Leussler's receive system, and are used in reconstructing **115** the displayed image. Leussler makes no suggestion of using the output of the surface imaging coils to adjust signal strength or phase in input RF signals.

**Claim 5** calls for a plurality of controllable high-frequency signal generators. Although the Examiner refers the applicant to control units **108** of Leussler, there is no suggestion in Leussler that the control units **108** contain high-frequency signal generators. Moreover, the high-frequency signal generators are claimed as generating the low power transmit signals, i.e., the signals which the first multiplexer/distributor network **receives**. Control units **108** of Leussler are downstream from the distributor unit **106** of Leussler.

**Claim 7** calls for a plurality of receive channels assigned to the respective resonator elements and **claim 10** adds transmit/receive switches which connect each resonator with the transmit channels and the receive channels. That is, claim 10 calls for an array of transmit/receive switches in addition to the second multiplexing/distribution network.

For these and other reasons, it is further submitted that the dependent claims distinguish for many more reasons over the references of record.

The applicants have added a new independent **claim 11**, which is similar to claim 1, but sets forth the concepts in more conventional, multi-paragraph format and, it is hoped, with clearer language. Care has been taken in drafting new **claim 11** to be sure that it distinguishes patentably and unobviously over the references of record. New method **claims 18 and 19** have also been added.

#### The Present Application

The applicants are submitting one page of substitute drawings, in which labels have been added to boxes **108, 109, 110, 114, 119, 120, and 122**. An early indication that the substitute drawings have been accepted is requested.

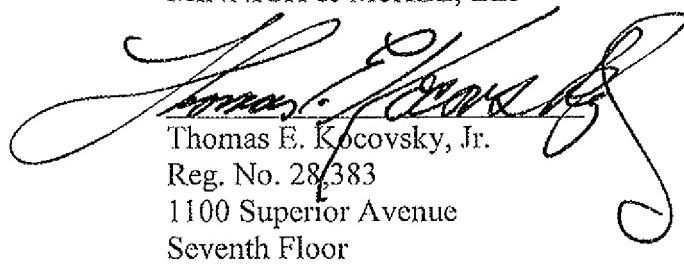
#### CONCLUSION

For the reasons set forth above, it is submitted that claims 1-19 (all claims) distinguish patentably over the references of record and meet all statutory requirements. An early allowance of all claims is requested.

In the event the Examiner considers personal contact advantageous to the disposition of this case, she is requested to telephone Thomas Kocovsky at (216) 861-5582.

Respectfully submitted,

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